TOPIC - Can inhalation of even one particle of plutonium result in cancer in humans?

The results of a study by Hei, et al (1997) have been misinterpreted and misapplied by some interested parties. It is important to consider that the cells in this study were plated in a single layer in a petri dish, then an alpha beam was aimed directly at their nuclei. These situations do not mirror the conditions a multi-celled organism would experience in the real world. An external alpha particle would be blocked by the dead cells of our skin. An ingested alpha particle would be blocked by the very rapidly recycled (or already dead) cells lining the digestive tract. Even if a mutation was induced by an alpha particle, the majority of mutations are dead ends and do not lead to cancer or even a pre-cancerous condition. Cancer is the result of many separate mutations; one mutation is not cancer.

Research has shown that a person would have to inhale large amounts of plutonium-contaminated dust particles to have a significant radiation exposure. One study concludes that, "Based on our calculations, millions of dust particles contaminated with PuO_2 [plutonium oxide] must be inhaled in order for significant radiation doses to be delivered to key body organs/tissues (bone surface, red marrow, lung, liver)". (Scott, B.R., et al, 1999, *Recommendations for improving the interim radionuclide soil action levels for the Rocky Flats Cleanup Agreement*, Lovelace Respiratory Research Institute.) This conclusion is based on several multiple-particle intake distributions generated for PuO_2 from re-suspended soil deposited in the respiratory tract. The mean intake of plutonium resulting from inhaling a certain number of contaminated dust particles from soils with a specific activity can be derived from these distributions. As an example, if someone breathed in a million dust particles from soil contaminated with plutonium at an activity level of 6.5 pCi/g (highest level measured off-site), the average intake is predicted to be only about 2.4×10^{-4} pCi (0.00024 pCi/g). These distributions demonstrate that although it may be possible for smaller numbers of plutonium particles to induce cancer in some individuals, it is highly unlikely. So in theory, a single exposure could initiate the chain of events which lead to cancer, but exposures that induce cancer risks below 1 in a million are considered to be negligible.

The number of DNA damage episodes occurring in a mammalian cell per day is high (more than 60,000 per day). Frequent occurrence of DNA damage is likely a problem for all DNA- containing organisms, and the need to cope with DNA damage and minimize their deleterious effects is likely a fundamental problem for life.[Bernstein, H; Bernstein, C (2013). "Evolutionary Origin and Adaptive Function of Meiosis". In Bernstein, Carol. *Meiosis*. InTech. ISBN 978-953-51-1197-9.]

Excerpts from:
Sutcliffe, W.G., et al. 1995. *A Perspective on the Dangers of Plutonium*. Center for Security and Technology Studies, Lawrence Livermore National Laboratory. CSTS-48-95. April.

Although the popular myth that "plutonium is the most hazardous substance known to man" has been refuted many times, the misconception persists that even a small amount of plutonium taken into the body will be fatal. Plutonium is hazardous, but it is not as immediately hazardous to health as many more common chemicals.

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Plutonium exposure may produce acute health effects (e.g., inhalation may lead to pulmonary edema, and ingestion to damage to GI tract walls), or long-term effects, such as increased risk of cancer mortality. Relatively high doses are required to produce acute effects. Ingestion of about 0.5 grams of plutonium would be necessary to deliver an acutely lethal dose. (For comparison, ingestion of less than 0.1 gram of cyanide can cause sudden death.) Inhalation of about 20 milligrams of plutonium dust of optimal size would be necessary to cause death within roughly a month from pulmonary fibrosis or pulmonary edema. As we explain below, it is hard to imagine scenarios in which a person would ingest or inhale such quantities of plutonium.

People inhaling less than acutely lethal quantities of plutonium will still have an increased probability of getting cancer. The lungs are exposed to alpha-particle radiation, increasing the risk of lung cancer, until the plutonium is (eventually) carried to other organs, primarily the bones and liver, where the radiation causes cell damage and increases the likelihood of cancer at those sites.

The committed effective doses and the increased probability of cancer death resulting from them have been studied extensively, as outlined in Appendix A. The estimated cancer fatality risk associated with exposure to weapons-grade plutonium is 12 cancer deaths per milligram inhaled, or 1 per 0.08 milligrams inhaled; and it is 0.0021 cancer deaths per milligram ingested, or 1 per 480 milligrams ingested. For perspective, an inhaled mass of about 0.0001 milligram would increase the cancer mortality from about 200 in 1000 (the risk of cancer mortality from all causes) to about 201.2 in 1000. This risk increase corresponds to a decrease in life expectancy of about 15 days; for comparison, smoking a pack of cigarettes a day reduces life expectancy by about 2250 days (more than six years).

It is important to understand the claims made in the press concerning particles of plutonium in the air. *The New York Times* says that "A tiny speck of the fine powder can cause lung cancer in anyone who inhales it." The largest speck of plutonium that can be readily inhaled is about 3 micrometers in diameter and has a mass of about 0.14 millionths of a milligram. The risk of dying of cancer as a result of inhaling that amount of plutonium is about 0.0000017 (12 cancers per milligram x 0.00000014 milligrams = 0.0000017 cancers, or 0.00017% additional risk); that is not zero risk, but it is very small.

The *Los Angeles Times* says that one ten thousandth of a gram (0.1 milligram) inhaled can cause cancer. This is correct: we have already estimated that 0.08 milligrams inhaled will have 100% probability of causing a fatal cancer. To inhale 0.1 milligram of plutonium, however, a person would have to inhale more than seven hundred thousand particles. (A single 0.1-milligram particle would have a diameter of over 260 micrometers, about 90 times too big to be readily inhaled.) Although a single respirable particle is unlikely to harm an individual, there is still cause for concern if plutonium were to be dispersed in the atmosphere.